IMPROVEMENT OF FIFTH ST. ROAD AT LA SALLE, ILLINOIS

R. G. ELIEL
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ARMOUR INSTITUTE OF TECHNOLOGY

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DESIGN AND ESTIMATE

OF

THE IMPROVEMENT OF THE FIFTH STREET ROAD

THROUGH

THE LITTLE VERMILLION VALLEY

AT

LA SALLE, ILL.

A THESIS PRESENTED

BY

R. G. Eliel.
Wm Clarkson Jr.
J. M. Eckert.

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

HAVING COMPLETED THE PRESCRIBED COURSE

IN

CIVIL ENGINEERING

CHICAGO, ILL.

1910. 31

Alfred E. Phillips
Professor of Civil Engineering.

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Dean.

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Dean.

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THE IMPROVEMENT OF THE FIFTH STREET ROAD AT LA SALLE, ILL.

The Fifth Street Road at La Salle, Ill. is the main thoroughfare leading from that city to the small towns in the east and northeast. It leads to some of the richest farm lands in that part of the state and it is practically the only way in which the farmers in the outlying districts can reach the city to bring in their produce and take out their supplies. Besides being the main highway used by farmers it is the best and most direct route by which automobiles passing through La Salle may reach Chicago and the numerous smaller cities between Chicago and La Salle.

Just as the road leaves La Salle it crosses the valley of the Little Vermilion Cfeek, a small winding stream which in the dry season has a width of about 75 feet; but in time of floods or a very rainy spring overflows it's banks and spreads over the greater part of the valley. At the point of crossing the valley has a width of about 1000 feet, and is very flat, the average height above mean water level being about 1 foot.

The valley's sides slope at rather a sharp angle and are marked by many small streams which afford the drainage for the high ground on either side. The geological structure is quite uniform, the surrounding country showing a limestone formation, which is cover-

ed to a depth of six or eight feet by a sticky brown clay.

At the present time the valley is crossed by a fill leading down from either side to an old masonry arch bridge, but the grades are very steep, and because of the lack of care and attention it is almost impossible for a loaded team to cross the valley in wet weather. The fill is of clay and is very poorly drained, thus leaving large pools of mud and water standing at points near the bottom of the grades and on the bridge. The road as it is now has a drop of about 60 feet in 800 or 900 feet, and has a grade varying from 4% to 10% or 12%.

The masonry bridge which spans the creek is a circular arch having a span of 75'-0", a rise of 15'-0", and a width at the springings of 24'-0". The arch ring is of uniform thickness throughout, having a depth of 3.3 feet at the crown and springings. The height of the springings above water level is about 5 feet and the distance between the surface of the roadway and the bottom of the arch ring is 7 feet, making the height of the roadway above water level about 27 feet.

The project taken up in this design is to raise the bridge to such a height that the maximum grade at any point on the approaches to the bridge will be $3\frac{1}{2}\%$. The old bridge and wing walls are to be taken out and replaced by reinforced concrete abutments and wing walls founded on bed rock and of the proper height to give the required grades, and the creek is to be spanned by a deck plate girder bridge having a span of 80 feet. Also the curve in the road on the east side of the valley is to be taken out as shown on the map and the new cut will be made to come into line with the old road on the top of the east bluff.

THE SURVEY.

In order to draw a profile of the valley, establish the proper grades, and draw cross sections of the present and proposed roads it was necessary to have a topographical map of the valley adjoining the road. The survey for the topography was made by the stadia method, the magnetic meridian being taken as the line of reference. In running the traverse the instrument was set up on the east side of the valley and a line run west along the road, side shots being taken on all points where required. The line was continued west to the opposite side, shots being taken on each side of the road on all fence corners, alleys, and important buildings as far as the Illinois Central tracks; and was then run down into the valley and back towards the starting point along the south side of the bridge, crossing the road on the east side of the valley and returning west along the north side of the bridge. In this way the topography of the valley for a distance of about 200 feet on each side of the road was determined.

The map was plotted from these stadia notes, and from a set of level notes taken along the center of the road and over the line of the proposed road the profile was obtained, and cross sections were plotted at equal distances along the profile. Then by means of the grade lines drawn on the profile the sections showing the cut and fill of the new road were drawn in. This gave a basis for the determination of the height of walls, height of abutments, length of wing walls, and amount of cut and fill together with the length of haul of the material from the cut to the fill and from the

TEXT OF ESSAY

borrow pile to the fill.

DESIGN OF THE RETAINING WALLS AND ABUTMENTS.

The retaining walls and abutments are of reinforced concrete, the abutments being founded on bed rock and the retaining walls going to a suitable depth to give stability.

The abutments are 55'-0" from bed rock to the surface of the roadway and are provided with bridge seats for a deck plate girder bridge, all dimensions being shown on the drawings. The abutment walls are provided with counterforts and are reinforced by the horizontal brace as shown.

The wing walls are designed by figureing the abutment walls and also the walls at the lower end and gradually decreasing from the abutment to the small end wall as shown on the plan and elevation sheet. The lower end of the wall has a height from bottom of footing to top of wall of 14'-0" and is built with counterforts the same as the abutments. Complete dimensions and details are shown on the drawings. Throughout the design the weight of concrete has been assumed as 150 pounds per cubic foot, the weight of earth as 120 pounds per cubic foot, and the slope of the earth fill as 1-1/2 to 1.

The pressure P' on the vertical plane 2-B is calculated graphically and equals the area SEN x 120 = 130,300 pounds and acts at an angle of 33 degrees. Therefore P'=100,100 pounds horizontal pressure which acts through the center of gravity and is equal to B 2 4.

J-1½ to I.

The resultant pressure on the plane G 2 is thus found to be (area G 23 x 120) = P".

P"= 88,900 pounds.

The weight of the prism of filling 012G = 148.100 pounds, and combined with P' gives P=180,100. The weight of the wall per lineal foot equals 51,400 pounds and combining this with P gives E = 224,000 pounds.

The resultant E cuts the base at a distance 3.2 feet from the center of gravity and the vertical component of E acting through this point is F = 200,000 pounds.

Stress diagrams.

$p_{'} = \frac{F}{AB} = \frac{200,000}{35} = 5,700$ pounds per square foot.

$p_{''} = \frac{6Fb}{d^2} = 6 \times \frac{200,000 \times 3.2}{(35)^2} = 3,127$ pounds per square foot.

$p = p_{'} \pm p_{''} = 8,827$ pounds per square foot or 2,573 pounds per square foot.

VERTICAL WALL OR SLAB.

The counterforts are to be spaced 10'-0' center to center and designed as a simple beam.

$M = \frac{wl^2}{8} = \frac{3450 \times (10)^2}{8} = 43,125$ foot pounds.

$M_s = Kbd^2$

Assume the thickness of beam = 24". n = 12, p = .006, f = 16,000. From calculation D = 22.4". Therefore the assumed thickness is safe.

Area of steel = pbd = .006 x 24 x 12 = 1.73 square inches.

To give the required amount of steel use 1 1/16" round rods 6" center to center, decreasing the spacing according th the decreasing pressure towards the top.

The resultant pressure on the piece G 2 is then found to be (see G 22 x 1200) = P".

P" = 86,800 pounds.

The weight of the price of tiling OLTG = 140,100 pounds, and combined with P' gives P=180,100. The weight of the wall per lineal foot equals 21,400 pounds and combining this with P gives R = 224,000 pounds.

The resultant R cuts the base at a distance 3.2 feet from the center of gravity and the vertical component of R acting through this point is V = 200,000 pounds.

Stress diagrams.

$$p' = \frac{V}{B} = \frac{200,000}{33} = 3,400 \text{ pounds per square foot.}$$

$$p'' = \frac{6Pe}{d^2} = \frac{6 \times 86,800 \times 3.2}{(33)^3} = 3,127 \text{ pounds per square foot.}$$

$$p = p' \pm p'' = 8,882 \text{ pounds per square foot or } 3,272 \text{ pounds per square foot.}$$

COUNTERFORT WALL OR BUTT.

The counterforts are to be spaced 10'-0" center to center and designed as a simple beam.

$$M = \frac{wl}{8} = \frac{3430 \times 10)^2}{8} = 42,125 \text{ foot pounds.}$$

$$R' = Kbd^2$$

Assume the thickness of beam = 14". n = 12, p = .006, F = 16,000. Area of steel = pbd = .006 x 14 x 12 = 1.72 square inches. From code section D = 22.4". Therefore the assumed thickness is safe

COUNTERFORTS.

The bending moment at the base along OG = M' = (88,900 x 10 x 18-1/3 = 1,629,833 foot pounds = 195,580,000 inch pounds. Assuming the thickness of the counterforts as 3'-0",

$M = \frac{195,580,000}{3 \times 12} = 5,432,777$ inch pounds.

$M = Kbd^2$ Taking p = .006, n = 12, f = 16,000. From calculation d = 21'-0". The assumed value of d is 26' and is therefore safe.

$K = \frac{M}{bd^2} = \frac{5,433,000}{1 \times (26 \times 12)^2} = 56$. This will require P = .004.

$A_s = pbd = .004 \times 36 \times (26 \times 12) = 44.9$ square inches. To give the required amount of steel use 12 - 2" square bars, decreasing the number of bars according to the decreasing pressure towards the top.

DESIGN OF THE BRACE.

The brace abcd is designed as a cantelever beam. The weight of the earth supported equals 17 x 40 x 120 = 81,600 pounds, and the uniform load on the beam equals $\frac{81,600}{17} = 4,800$ pounds per lineal foot.

$M = \frac{wl}{2} = 4800 \times \frac{17}{2} = 40,800$ foot pounds.

$M = Kbd^2$ Assume the thickness of the brace = 36". n = 12, p = .003, f = 16,000. From calculations d = 30.45".

$A_s = pbd = .003 \times 36 \times 12 = 1.29$ square inches. To give the required amount of steel use 7/8" round rods spaced 6" center to center.

THE BRIDGE SEAT.

$M = \frac{wl^2}{8} = \frac{600 \times (10)^2}{8} = 7500$ foot pounds.

c.

$M = Kbd^2$. Assume the thickness as 10". n = 12, p = .006, f = 16,000. From calculations d = 9.33".

$A_s = pbd = .006 \times 10 \times 12 = .72$ square inches. To give the required amount of steel use 1" round rods, 6" center to center.

FOUNDATIONS.

Referring to the stress diagram the moment of $K = M' = \frac{(8,800 + 7,400)8 \times 4.1}{2} = 282,080$ foot pounds.

$M = Kbd^2$.

n = 12, p = .01, f = 16,000. From calculations $d = \sqrt{\frac{282,000}{1 \times 83.8}} = 58.5"$ = 4.9' the depth at the toe. Since the moment is greatest at K we have made the thickness 8' and 4' at the toe.

$K = \frac{M}{bd^2} = \frac{282,000}{1(8 \times 12)^2} = 30.6$. This will require p = .003 when n = 12 and f = 16,000.

$A = pbd = .003 \times 96 = .288$ square inches.

To give the required amount of steel use 7/8" round rods 3" center to center at the bottom and 7/8" round rods 6" center to center at the top.

DESIGN OF THE LOWER END OF RETAINING WALL.

The wall at this point has a height of 14'-0", all other dimensions being the same as shown on the drawing, and all data being the same as used in the design of the main walls.

The area of the triangle SeN = 56.25' square feet. 56.25 x 120 = 6750 pounds acting at an angle of 33 degrees. Therefore the horizontal pressure P' = 5650 pounds.

The horizontal pressure on G2 = $\frac{5650 \times 2}{14}$ = 870 pounds.

The weight of the prism of earth 0-12-G = 7600 pounds and combining this with the horizontal pressure P' gives P = 9500 pounds. The weight of the wall = 4600 pounds and combining this with P gives E = 13,400 pounds and the resultant cuts the base within the middle third at a distance of .3 feet from the center of gravity and the vertical component of E acting through this point is F = 12,150 lbs.

Stress Diagrams.

$p_1 = \frac{F}{AB} = \frac{12,150}{11}$ = 1105 pounds per square foot.

$p_{11} = \frac{6Fb}{d^2} = \frac{6 \times 12,150 \times .3}{11^2}$ = 181 pounds per square foot.

$p = p_1 \pm p_{11}$ = 1272 pounds per square foot or 924 pounds per square foot.

SLAB.

The counterforts are to be spaced 10' center to center.

$M = \frac{wl^2}{8} = \frac{710 \times 10^2}{8}$ = 8,875 foot pounds.

$M = Kbd^2$. Assume the thickness of the wall as 12". n = 12, p = .006, f = 16,000. From calculations d = 11.2".

$A_s = pbd$ = .006 x 12 x 12 = .864 square inches.

DESIGN OF RIB FOR A NO OF CANTILEVER BEAMS.

The wall at this point has a height of 14'-0", all other dimensions being the same as shown on the drawing, and all data being the same as used in the design of the main walls.

The area of the triangle ted = 7C.4.5' square feet.

56.5 x 120 = 6720 pounds acting at an angle of 30 degrees. Therefore the horizontal pressure P' = 5820 pounds.

The horizontal pressure on BC = $\frac{5820 \times 3}{14}$ = 1245 pounds.

The weight of the prism of earth C-BB-C = 7800 pounds and combining this with the horizontal pressure P' gives P = 7900 pounds. The weight of the wall = 4510 pounds and combining this with P gives R = 13,410 pounds and the resultant cuts the base within the middle third at a distance of .7 feet from the center of gravity and the vertical component of R acting through this point is = 12,120 lbs.

Stress Diagram.

$f_1' = \frac{12,120}{12}$ = 1176 pounds per square foot.

$p' = \frac{6 \times 12,120 \times .7}{12^2}$ = 183 pounds per square foot.

f = P' + p' = 1474 pounds per square foot or 10.4 pounds per square inch.

Shear.

The compression are to be stood 12' center to center.

$\frac{R}{8} = \frac{120 \times 10}{8}$ = 8,070 lbs pounds.

Z = 4.4. Assume the thickness of the wall as 12". d = 10, y = .

I = 12,000. From calculations I = 11.4".

A_1 = bpi = .5 x 12 x 22 = .664 square inches.

To give the required amount of steel use 1-1/16" round rods 12" center to center, decreasing the number of bars according to the decrease in pressure towards the top.

COUNTERFORTS.

The bending moment at OG = M' = 4380 x 4.1 x 10 = 179,580 foot pounds, = 2,154,960 inch pounds.

Assuming the thickness of the counterforts as 12" M = $\frac{2,154,960}{12}$ = 179,588 pounds.

$M = Kbd^2$. Assuming n = 12, p = .003, f = 16,000, from calculations d = 5'-4". The assumed value of d is 6'-6" and is therefore safe.

$A_s = pbd = .003 \times 12$.

$K = \frac{M.}{bd^2} = \frac{2,154,960}{(6\ 1/2 \times 12)^2} = 29.5$. This will require p = .002.

$A_s = pbd = .002 \times 78 \times 12 = 1.87$ square inches. To give the required amount of steel use 2 - 1" square bars.

The first three counterforts are 1'-0" thick reinforced with 2- 1" square bars 6" center to center. The first two counterforts adjoining the abutment shall be the same as those of the abutment All intermediate counterforts are 2'-0" thick, the reinforcing being decreased as the lower end of the wall is approached.

FOUNDATION.

Referring to the stress diagrams the moment at K = M' = $\frac{1272 + 1120}{2} \times 3\text{-}1/2 \times 2.3 = 9628$ foot pounds.

$M = Kbd^2$.

n = 12, p = .006, f = 16,000. $d = \sqrt{\frac{9628}{1 \times 70.3}} = 13.7"$. The assumed

depth at the toe = 20".

$K = \frac{M}{bd^2} = \frac{9628}{1 \times 20^2} = 24$. This will require p = .002.

A_s = pbd = .002 x 20 = .04 square inches, per inch of thickness. To give the required amount of steel use 7/8" round rods 12" center to center at the bottom and 7/8" round rods 24" center to center at the top.

- NOTE -

In order to take care of the temperature stresses the steel is placed horizontally and vertically in the counterforts as shown in the drawings.

in one word.

MAXIMUM SHEAR ALLOWED ON CONCRETE.

The maximum shear allowed on beams and walls shall be 75 lbs. per square foot.

MAXIMUM STRESS ALLOWED ON STEEL.

In the beams and walls the steel shall be assumed to take the entire tensile stress without aid from the concrete, and shall have an area sufficient to equal the compressive strength of concrete composed of one part Portland Cement, three parts Sand, and six parts of broken stone, of the age of six months. The value of the steel in tension will be assumed as 15,000 lbs. per square inch.

DISCREPANCIES.

In the event of any discrepancies between the drawings and the figures written on them, the figures are to be taken as correct, and in case of any discrepancies between the drawings and the specifications, the specifications are to be adhered to.

FOUNDATIONS.

All foundations shall be as shown on plans, and conform to the dimensions marked thereon. Foundations are to be on gravel and shall be excavated to a depth of 12'-0".

CEMENT.

No cement will be allowed to be used except German-American Portland Cement. All cement shall have been seasoned or subjected to aeration for at least 30 days before leaving the factory. All cement shall be dry and free from lumps, and immediately upon receipt shall be stored in a dry, well covered and ventilated place, thoroughly protected from the weather. The fineness of the cement shall be such that at least 90% will pass through a sieve of # 40 wire, Stubbs gauge, having 10,000 openings per square inch, and at

least 75% will pass through a sieve of # 45 wire, Stubbs gauge, having 40,000 openings per square inch.

Samples for testing shall be taken from every tenth barrel. The samples will be mixed thoroughly together while dry and the mixture be taken as the sample for test.

The sand used in preparing test specimens shall be clean, sharp crushed quartz, retained on a sieve of 30 meshes per lineal inch and passing through a sieve of 20 meshes per lineal inch. In test specimens of 1 cement and 3 sand, no more than 12% of water by weight shall be used. Specimens prepared from a mixture of 1 part cement and 3 parts sand, parts by weight, shall after 7 days develope a tensil strength of not less than 170 lbs. per square inch, and not less than 240 lbs. per square inch after 28 days. Cement mixed neat with from 20% to 25% of water to form a stiff paste shall after 30 minutes be appreciably indented by the end of a wire $\frac{1}{12}$" in diameter loaded to weigh $\frac{1}{4}$ lb. Cement made into thin pats on glass plates shall not crack, scale, nor warp under the following treatment: 3 pats are to be made and allowed to harden in moist air from 60 to 70 degrees Fahr.; one of these will be placed in fresh water for 28 days, another to be placed in water which will be raised to the boil ing point for 6 hours and then allowed to cool, and the 3rd to be kept in air of the prevailing outdoor temperature.

PORTLAND CEMENT CONCRETE.

The concrete shall be composed of cement, sand and gravel, mixed in clean water in the proportions hereafter mentioned.

The sand shall be clean, sharp and coarse, or coarse and f fine mixed, free from sewage, mud, clay and all foreign matter.

The gravel shall be of assorted sizes screened or washed entirely free from clay, loam, or foreign matter, and be free from scale, slime, or humus.

The ingredients shall be placed in the machine in a dry state and in the volumn specified, and be thoroughly mixed, after which clean water shall be added and the mixing continued until the wet mixture is thorough and the mass uniform. The mixture shall be sufficiently wet for the water to come to the surface with moderate ramming. As soon as the batch is mixed it must be deposited in the work without delay.

All concrete shall be deposited in layers of 6" or 8", and be thoroughly rammed until all voids are filled and the water flushes to the surface.

All concrete shall be mixed in the following proportions: 1 part Portland Cement, 3 parts Sand, and six parts of Gravel that will pass through a 3" ring.

ARTIFICIAL STONE.

The concrete shall be rammed directly against the molds, and after the molds have been removed all exposed surfaces shall be floated to a smooth finish with a morter consisting of 1 part cement and 2 parts of fine sharp sand, care being taken that no body of morter is left on the face, suffient only being used to fill the pores and give a smooth finish.

MIXTURES.

The volumes of cement, sand and gravel, in all mixtures of morter or concrete shall be measured loose.

CONNECTIONS.

In connecting concrete already set with new concrete, the

surface shall be cleaned and roughened, and mopped with a morter composed of 1 part cement and 1 part sand to cement the parts together.

DRAINAGE.

Provision for drainage shall be made at each point shown on drawings as follows: a wrought iron pipe $1\frac{1}{2}$" in diameter shall be placed between each two counterforts at the top of the foundation and also above the brace located midway of the height of the abutment wall. The line of drainage shall be covered with a layer of broken stone, and the top of the pipes shall be provided with screens to prevent clogging.

STEEL.

Steel rods shall be imbedded near the tension side of all members subjected to transverse stresses.

The distance of the center of the rod from the outside of the concrete shall not be less than the diameter of the rod. All steel must be free from paint and oil, and all scale and rust must be removed before imbedding in the concrete.

The tensile strength, limit of elasticity and ductility shall be determined from a test piece cut from the thinest material and turned and planed parallel. The area of cross section shall not be less than $\frac{1}{2}$" square inch; the elongation shall be measured after breaking on an original length of 8". Each melt shall be tested for tension and bending.

Medium steel shall be used in all concrete work and shall have an ultimate strength of from 60,000 to 68,000 lbs. per square inch, an elastic limite of not less than $\frac{1}{2}$ the ultimate strength,

cover.

shall elongate not less than 22% in 8", and bend cold 180 degrees to a diameter equal to the thickness of the piece tested without fracture on the outside of bend. In tension tests the fracture must be entirely silky. The workmanship must be first class.

FORMS.

All walls, abutments and foundations shall be built in timber forms. These forms shall be made of first class timber, free from knots and other imperfections. Forms shall be built substantial and unyielding, and of the proper dimensions for the work intended. All parts in contact with exposed faces of concrete shall be well spaded. Bracings shall be placed at all points where necessary and care shall be taken that all joints and corners are well closed.

WATERPROOFING.

The inner surfaces of all retaining walls and abutments shall be coated with a heavy coat of semi-liquid mortar, consisting of 1 part cement, $\frac{1}{2}$ part of thoroughly slaked lime, and 3 parts of sand, spread to leave a smooth finish, and after this has set hard it shall be given a heavy coat of pure cement grout.

NAMEPLATES.

Two nameplates shall be furnished by the contractor. They shall be of a design approved by the engineer, and built into the abutment or such other place as may be directed by the engineer, 1 plate being inscribed with the names of the city or county officials and year of completion, the other being inscribed with the names of the designers and contractors. The plates shall be made of cast iron and they shall be given 2 coats of bronze paint and 2 coats of best varnish.

ERECTION.

The contractor shall employ competent and suitable labor for every kind of work. The contractor shall furnish all staging, piling, cribbing, casing and material of every description required in the erection of the work; also all plant, including dredges, engines, pumps, barges, piledrivers, derricks, mixing machines, conveyors or all other appliances necessary for carrying on all parts of the work. The contractor shall make all the provisions necessary to maintain and protect buildings, fences, trees, conduits, sewers and other structures, and shall repair all damage occasioned; shall provide watchmen, red lights, fences, and other precautionary measures necessary for the protection of person and property. The contracot shall assume all risks for loss or damage incurred by ice, floods, fire or other causes during the construction of the work, and until the same is accepted.

WORK EMBRACED BY THE CONTRACT.

The contractor shall do all the work prescribed in these specifications and as shown on the plans from out to out of retaining walls.

CLEANING UP.

After the completion of the work and before final acceptance thereof, the contractor shall remove all temporary structures and rubbish, and leave the work and surrounding ground in a neat and satisfactory condition.

MAINTAINING PUBLIC TRAVEL.

If public travel is to be maintained during the construction of the new bridge a temporary bridge shall be erected by the contractor.

Insurance.

The contractor shall employ competent and skilled labor for every kind of work. The contractor shall furnish all equipment, drilling, excavating and material of every description required in the execution of the work; also all plant, including boilers, engines, pumps, derricks, platforms, derricks, guys, ropes, cables, tackle, blocks, and all other appliances necessary for the proper prosecution of the work. The contractor shall give all the necessary notices required by statute and pay all taxes, contributions, duties and other charges, and shall comply with all provisions of statutes and by-laws, and shall provide watchmen, red lights, fences and other precautions necessary for the protection of persons and property. The contractor shall assume all risks for damage or injury to, loss, theft, fire or other causes during the construction of the work, and shall be responsible.

Clearing up.

After the completion of the work and before the final measurement, the contractor shall remove all temporary structures and material, and leave the site and surrounding ground in a tidy condition.

Liability for Claims.

If public travel is to be interfered during the progress of the work, the contractor shall provide temporary bridges and crossings.

REMOVAL OF THE OLD BRIDGE.

The present bridge and all retaining walls shall be removed by the contractor. All stone shall become the property of the contractor and may be used by him in the erection of the new work.

ENGINEER.

Wherever the word "engineer" appears in these specifications, the same shall mean the engineer or other public official who may be properly authorized to act for the party who makes this contract with the contractor.

LINES AND GRADES.

Lines and Grades shall be established by the engineer, and no work shall be attempted or commenced until these are given.

EXTRA WORK.

The contractor must be prepared to do any extra work that may be ordered in writing by the engineer, and for this he shall be paid at current contract rates for work of a similar character, or if the extra work should be of a class for which no rate is fixed by current contracts, the actual reasonable cost to the contractor, as determined by the engineer, plus 15% of said cost. The contractor shall have no claim for compensation for extra work unless the same is ordered in writing by the engineer.

INSPECTION.

All the material furnished by the contractor shall be subject to the inspection and approval of the engineer, and the engineer shall have power to condemn all work which in his opinion is not done in accordance with this contract and specifications.

MODIFICATIONS.

Any modifications of prescribed lines, grades, positions,

methods, or materials of construction which in the judgement of the engineer may be expedient, shall be made by the contractor.

INTERPRETATION OF PLANS AND SPECIFICATIONS.

The decision of the engineer shall control as to the interpretation of the plans and specifications during the execution of the work thereunder, but this shall not deprive the contractor of his lawful rights to redress after the completion of the work for any improper orders or decisions which may have been received during the execution of the work.

ESTIMATES.

Approximate estimates of the work done and material furnished shall be made on or about the last day of every month, and a valuation of the same in proportion to contract prices for the completed work will be made by the engineer, which sum will be paid to the contractor in cash on or about the 10th day of the following month, less a deduction of 10% upon said valuation, which shall be retained until the final completion of the work.

FINAL PAYMENT.

Upon the completion of the work the contractor shall be promptly paid the balance of the contract price which shall then remain due and unpaid.

COST ESTIMATE OF WALLS AND ABUTMENTS.

STEEL.

FOUNDATIONS.

No.	SIZE.	LENGTH IN FEET.	TOTAL LENGTH.	WEIGHT PER FT.
100	7/8" Rd.	34'	3400'	2.044
130	" "	10' to 34'	2860'	"
10	" "	152'	1520'	"
10	" "	80'	800'	"
15	" "	40'	600'	"
TOTAL-			9180'	
		TOTAL WEIGHT = 18.766 lbs.		

CENTRAL WALL.

19	1" Rd.	55'	1045'	2.67
80	1" Rd	12' to 50'	2480'	"
TOTAL-			3425'	
		TOTAL WEIGHT = 9411 lbs.		
11	1-1/16" Rd.	155'	1705'	3.014
15	" "	120'	1800'	"
15	" "	70'	1050'	"
19	" "	30'	570'	"
TOTAL-			5125'	
		TOTAL WEIGHT = 15,447 lbs.		

BRACE.

40	7/8" Rd	28'	1120'	2.044
15	" "	17'	255'	"
TOTAL-			1375'	
		TOTAL WEIGHT = 2811 lbs.		

COUNTERFORTS.

No.	SIZE.	LENGTH IN FEET.	TOTAL LENGTH.	WEIGHT PER FT.
18	2" Sq.	62'	1116'	13.6
18	" "	50'	900'	"
12	" "	45'	540'	"
12	" "	35'	420'	"
10	" "	42'	420'	"
10	" "	30'	300'	"
8	" "	25'	200'	"
8	" "	36'	288'	"
4	" "	30'	120'	"
4	" "	20'	80'	"
TOTAL-			4384'	
		TOTAL WEIGHT =	59,623 lbs.	
4	1" Sq.	23'	92'	3.4
6	" "	15'	90'	"
TOTAL-			182'	
		TOTAL WEIGHT =	619 lbs.	

Weight in Foundation - - - -	18,766 lbs.
Weight in Central Wall - - -	24,858 lbs.
Weight in Brace - - - -- - -	2,811 lbs.
Weight in Counterforts - - -	60,242 lbs.
TOTAL WEIGHT OF STEEL - - -	106,677 lbs.
COST PER POUND IN PLACE- - -	$.03
TOTAL COST OF REINFORCING- -	$3200.31

CONCRETE.

VOLUME OF CONCRETE IN FOUNDATION. = 10,380 Cubic Feet.

" " " " WALL = 14,131 Cubic Feet.

" " " " COUNTERFORTS= 11,840 Cubic Feet.

TOTAL- 36,351 Cubic Feet.

Equals-1,346 Cubic Yards.

The cost of materials delivered on the ground are:-

Sand - - - - - - - - - - - - - - - $1.15 per 2000#.

Gravel - - - - - - - - - - - - - - - $1.35 " " "

German-American Portland Cement - $1.00 per bbl.

Weight of sand per cubic yard = 3,000 lbs.

" " gravel " " " = 3,000 lbs.

Using a 1-3-6 mixture from Fuller's Rule for proportioning Concrete we get 1 + 3 + 6 = 10. 11/10 = 1-1/10 bbls. cement per cubic yard of concrete.

3 x 1.1 x .14 = .462 cubic yards of sand per cubic yard of concrete.

6 x 1.1 x .14 = .924 cubic yards of gravel " " " " " .

MATERIAL AND LABOR.

Sand --- .462 x 3,000 = 1386 lbs. @ $1.15 per 2,000 lbs.	=	.80
Gravel - .924 x 3,000 = 2772 lbs. @ $1.35 per 2000 lbs.	=	1.87
Cement - 1-1/10 bbls. of cement @ $1.00 per bbl.	=	1.10
Forms- - (Labor, timber, etc.)	=	1.25
Mixing and placing	=	1.00
Handling and incidentals.	=	.50
TOTAL COST PER YARD =		$6.52
TOTAL YARDAGE=	1346 cubic yards.	
TOTAL COST =	$8775,92.	

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DESIGN AND COST ESTIMATE OF THE BRIDGE.

The creek is to be spanned by a deck plate girder bridge having a span of 80'-0" center to center of bearings, and resting on the two bridge seats on the abutments designed as shown on drawings. The distance between centers of girders is to be 14'-0". The actual width of the bridge is 20'-0", a projection of 4'-0" being allowed on one side for a sidewalk and 2'-0" projection being left on the other side as part of the roadway. The bridge is designed according to "Cooper's Specifications for Highway Bridges", and has a loading of 12 tons on two axles 10'-0" center to center, the gauge of the wagon being 6'-0", and also a uniform load of 100 pounds per square foot. The floor is to be I beam construction; floor beams being laid accross the bridge at intervals of 8'-0" and the stringers being framed onto the floor beams. Distance center to center of stringers is 2'-0".

DESIGN OF MEMBERS.

STRINGER.

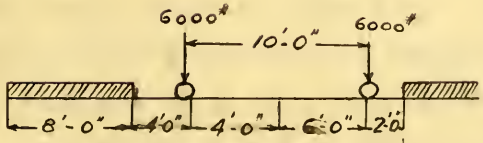


Fig.1.

The maximum bending moment in the stringer occurs when one of the wheels is midway between two panel points as shown in figure 1.

Maximum bending moment = $M = \frac{PL}{4} = \frac{6000 \times 8 \times 12}{4} = 144000$ inch lbs.

$M = \frac{SI}{C}$. The allowable unit stress S = 12000 lbs. $\therefore$ 144000 =

12000 $\frac{I}{C}$ or $\frac{I}{C}$ = 12. From the table of standard I beams in Carnegie a 7" 20# I beam is found to have a value of 12.1 for $\frac{I}{C}$ ∴ the roadway stringers will be 7" 20# I beams.

The sidewalk stringers are to carry a live load of 100# per square foot; this will make the load on each stringer = 8 x 2 x 100 = 1600 lbs. Maximum bending moment = M = $\frac{1}{8}$ WL. ∴ M = $\frac{1}{8}$ x 1600 x 8 x 12 = 19200 inch pounds. M = S $\frac{I}{C}$ ∴ 19200 = 12000 $\frac{I}{C}$ or $\frac{I}{C}$ = 1.6. From the table a 3" 5.5# I beam has a value of 1.7 for $\frac{I}{C}$ ∴ the sidewalk stringers are to be 3"-5.5# I beams.

The maximum stringer reaction will occur under the loading shown in figure 2, at panel point 2.

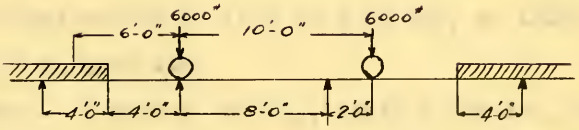


Fig. 2.

The reaction at panel point 2 = 6000 lbs. + the reaction at 2 due to the dead load in panel 1-2 or 6200 lbs.

DESIGN OF FLOOR BEAM.

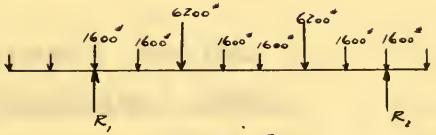


Fig. 3.

The loading shown in figure 3 will give the maximum floor beam reaction when the bridge is fully loaded, the wheel loads being over the stringers which will bring the load over the center of the bridge. The reaction R_I = R_{II} = one half of the sum of the loads. ∴ R_I = R_{II} = 9400 lbs.

The bending moment at the center = the reaction x $\frac{1}{2}$ the span = 9400 x 7 x 12 = 789600 inch lbs.

$M = S \frac{I}{C}$. $\therefore$ $789600 = 12000 \frac{I}{C}$ or $\frac{I}{C} = 65.8$. From the tables a 15"-55# I beam has a value of 68.1 for $\frac{I}{C}$ $\therefore$ all floor beams will be 15"-55# I beams.

DEAD LOADS DUE TO FLOOR SYSTEM, ETC.

Weight of stringers- 9 roadway stringers, length = 80', weight = 20# per lin. ft. Total weight = 9 x 80 x 20 = 14400 lbs. Weight for each girder = 7200 lbs.

2 sidewalk stringers- length = 80', weight = 5.5 lbs. per lin. ft. Total weight = 2 x 80 x 5.5 lbs. = 880 lbs.

Weight of floor beams:- 11 floor beams, length 20', weight 55 lbs. per lin. ft. Total weight = 11 x 20 x 55 lbs. = 12100 lbs. Weight for each girder = 6050 lbs.

Weight of floor:- length = 80 ft., width = 20 ft., thickness = $\frac{1}{4}$ ft. Weight of timber = 40 lbs. per cubic ft. Total weight = $80 \times 20 \times \frac{1}{4} \times 40$ lbs. = 16000 lbs. Weight for each girder = 8000 lbs.

The total weight of guard rails, curbing, nailing pieces, end railing = 4000 lbs.

Weight for each girder = 2000 lbs.

SUMMARY OF WEIGHTS FOR 1 GIRDER.

Stringers	7200 + 880	=	8080.
Floor Beams		=	6050.
Wooden floor		=	8000.
Railing, etc.		=	2000
Estimated weight of girder		=	18500
	Total-		42630.

$\therefore$ the dead panel load = $\frac{42630}{10}$ = 4263 lbs.

Live panel load = the floor beam reaction + 1600 lbs. = 9400 + 1600 =

Live part of load = the floor reaction $\frac{7}{12}$ 7000 lbs. = 4100 + 7000 =

$\therefore$ the dead panel load = $\frac{18800}{12}$ = 1566 lbs.

Total-	18830.
Modified weight of girder	= 18800
Ceiling, etc.	= 2000
Floor floor	= 8030.
Floor beams	= 800.
Weight	= 8030.

Weight for one girder = 8000 lbs.

The total weight of grand trib, ceiling, roofing, roofing pieces, and girding = 4000 lbs.

Weight for one girder = 8000 lbs.

Weight for one girder = 8000 lbs.

Weight of floor beams:- Length = 80 ft., width = 20 ft., thickness = $\frac{1}{2}$ ft. Weight of timber = 40 lbs. per cubic ft. Total weight = 80 x 20 x $\frac{1}{2}$ x 40 lbs. = 16000 lbs. Weight for each girder = 8000 lbs.

Weight of floor beams:- 11 floor beams, length 80', weight 7 lbs. per lin. ft. Total weight = 11 x 80 x 20 lbs. = 17600 lbs. Weight for each girder = 8800 lbs.

2 sidewall struts:- length = 80', weight = 3.6 lbs. per lin. ft. total weight = 2 x 80 x 3.6 lbs. = 880 lbs.

Weight of struts- 9 roadway struts, length = 80', weight = 80# per lin. ft. Total weight = 9 x 80 x 80 = 14400 lbs. Weight for each girder = 7400 lbs.

Dead Load to Panel Point, No.

Weight of struts- 9 roadway struts, length = 80', weight = 80# per lin. ft. Total weight = 9 x 80 x 80 = 14400 lbs. Weight for each girder = 7400 lbs.

2 sidewall struts:- length = 80', weight = 3.6 lbs. per lin. ft. total weight = 2 x 80 x 3.6 lbs. = 880 lbs.

Weight of floor beams:- 11 floor beams, length 80', weight 7 lbs. per lin. ft. Total weight = 11 x 80 x 20 lbs. = 17600 lbs. Weight for each girder = 8800 lbs.

Weight for one girder = 8000 lbs.

Weight of floor beams:- Length = 80 ft., width = 20 ft., thickness = $\frac{1}{2}$ ft. Weight of timber = 40 lbs. per cubic ft. Total weight = 80 x 20 x $\frac{1}{2}$ x 40 lbs. = 16000 lbs. Weight for each girder = 8000 lbs.

The total weight of grand trib, ceiling, roofing pieces, and girding = 4000 lbs.

Weight for one girder = 8000 lbs.

Dead Load to Panel Point, No.

Total-	18830.
Modified weight of girder	= 18800
Ceiling, etc.	= 2000
Floor floor	= 8030.
Floor beams	= 800.
Weight	= 8030.

Live part of load = the floor reaction $\frac{7}{12}$ 7000 lbs. = 4100 + 7000 =

$\therefore$ the dead panel load = $\frac{18800}{12}$ = 1566 lbs.

$\therefore$ the 12'-0" I beam a value of 98.1 for $\frac{I}{c}$. $\therefore$ all I for beams will be 12'-0" I beams.

$\therefore$ $\frac{I}{c}$ = 8. $\therefore$ 78800 = 12000 $\frac{I}{c}$ or $\frac{I}{c}$ = 87.8. From the price

11000 lbs.

The total panel load = the live load plus $\frac{1}{2}$ the dead load = 11000 + 2132 = 13132 lbs. = 14 kips.

DESIGN OF THE WEB.

The reaction = 4.5 x 14 = 63 K. The allowable unit stress of the web in shear = 9000 lbs. per square inch. Therefore- the area of the web required = $\frac{63}{9}$ = 7 square inches. According to specifications a $\frac{5"}{16}$ web is the thinest that may be used.

The gross area must be $\frac{3}{2}$ x 7 = 10.5 square inches , because for every diameter of metal $\frac{1}{3}$ has been taken out for rivets. The depth of the web = 96", therefore the required thickness = $\frac{10.5}{96}$ = .12 inches. This is less than $\frac{5"}{16}$ inch therefore a $\frac{5"}{16}$ web is O.K.

DESIGN OF THE FLANGES.

The maximum bending moment at the center of the girder is M = 63 x 40 - 8 x (1 + 2 + 3 + 4) 14 = 2520 - 1120 = 1400 K. ft.

1400 x 1000 x 12 = 16800000 inch lbs.

The flange angles are to be spaced with their backs $\frac{1"}{8}$ above the top of the web plate, making the depth back to back of the flange angles 96-$\frac{1}{4}$ inches. The distance of the center of gravity from the back of the flange angles was assumed as 1.5 inches. Therefore, the effective depth equals 96.25 - 3 = 93.25 inches. From the specifications the value of the steel in the flanges is 12500 lbs. per square inch, therefore the area required in the flanges = $\frac{16800000}{12500 \times 93.25}$ = 14.5 square inches; Try two angles 6"x 6"x $\frac{13}{16}$". Area = 2(9.09 - 1.5) = 15.18 square inches; the 1.5 square inches is deducted from the area of each angle to allow for material cut out for rivets. The distance of the center of gravity from the back of a 6" x 6" x $\frac{13}{16}$" angle is 1.8". Therefore, the true effective depth using two of these angles is 96.25 - 3.6 = 92.65"

lbs.

Total permanent load = The live load plus $\frac{1}{5}$ the dead load = lbs.

+ DEAD = TOTAL lbs. = Kips.

Length of one web.

Cross section = 4.5 x 14 = 63 Sq. In. The stress due unit stress of

in floor = 5000 lbs. per square inch. Therefore- the area of the

web required = $\frac{5}{63}$ = Say square inches. According to specifications

$\frac{1}{16}$ web is the thinest that may be used.

The gross area must be $\frac{5}{1.5}$ x Y = 10.3 square inches, Therefore for every difference of $\frac{1}{32}$ inch thickness = $\frac{1}{16}$ web is required.

The depth of the web = 10". Therefore the required thickness = $\frac{10}{16}$

= .12 inches. This is less than $\frac{1}{8}$" inch Therefore, $\frac{1}{16}$ web is required.

Length of Flange Angles.

40 - 2 x (1 + 2 + 3 + 4) 14 = Max. - Ded. = 1400 L. Ft.

1400 x 1000 x 12 = 16800000 Inch Lbs.

The maximum bending moment at the center of the girder is M = 20 x

Flange angles are to be spaced with their backs $\frac{5}{8}$

above the top of the web plate, making the depth back to back of

the flange angles 10-$\frac{1}{4}$ inches. The distance of the center of

gravity from the face of the flange angles not shown is 1.5 inches.

Therefore, the effective depth equals 10.375 - Y = 9.5 inches.

For the specifications the value of M as used in the flange is

16800 lbs. per square inch, therefore the area required is

Flange = $\frac{1680}{12000 \times 9.5}$ = 14.7 equared inches. By two angles

0" x 0"x $\frac{5}{16}$". Area = 8.44 - 1.41 = 7.03 square inches;

1.5 square inches is the total deduction for area of rivet holes; the

modified cut for rivets. The distance of the center of gravity

from the back is 0" x 0. $\frac{5}{16}$" equals is I.C". Therefore, the

area effective deph ing the of these angles is 20.38 - 3.0 = 17.38

The true area required = $\frac{16800000}{12500 \times 92.65}$ = 14.6 Square inches.
Since this is less than the area of the two angles, 2 angles 6" x 6" x $\frac{13}{16}$" are O. K.

THE WEB SPLICE.

96" plates are rolled in lengths up to 300", therefore it is necessary to have three splices in the web. Using four plates each 240" long will require splices at the 20, 40, and 60 foot sections. Since the web takes all the shear the heaviest splices will occur at the 20 and 60 foot sections, all splices being made the same as that designed for the 20 ft. section.

The maximum shear at the 20 ft. section = 63 - 2 x 14 = 35 K. The bearing value of a $\frac{7}{8}$" rivet on a $\frac{5}{16}$" plate = 4100 lbs. Therefore, the number of rivets required = $\frac{35000}{4100}$ = 8.5. If the rivets are spaced 4" apart the number of rivets in a 96" web = $\frac{96}{4}$ = 24, and taking out 1" for each rivet the effective depth = 96 - 24 = 72", and the net section = 72 x $\frac{5}{16}$" = 22.5 square inches. The web will resist 22.5 x 9000 = 202500 lbs. Since the strength of the rivets should be that of the web the number of rivets should be $\frac{202500}{4100}$ = 50 rivets. Two rows of rivets spaced 4" center to center are used. The splice plates must be $\frac{3}{8}$" thick and must be wide enough to take two rows of rivets on each side of the splice. Therefore, 2 plates 13" x $\frac{3}{8}$" will be used.

RIVET PITCH IN FLANGES.

The rivet pitch is calculated by the formula $p = \frac{Pd}{S}$.

P = the bearing value of 1 rivet = 4920 lbs.

S = the shear at the section.

d = the effective depth = 92.65 inches.

To find the pitch in the end panel- the maximum end shear = 63 K.

The plate area required = $\frac{\text{[illegible]}}{\text{[illegible]}}$ = 14.6 square inches.

[illegible] = $\frac{14}{16}$" use 1".

[illegible]

[illegible] plates are to [illegible] to 30", therefore it is necessary to have three splices in the web. Using four rivets etc (4") long will require spacing at one 3", two 6" four sections. [illegible] the [illegible] will occur at the [illegible] section, all splices being made the same as that required for the 30" section.

The vertical shear at the 20 ft. section = 82 - 2 x 14 = 54 K. The bearing value of 1 $\frac{7}{8}$" rivet or a $\frac{7}{16}$" plate = 4100 lbs. Therefore, the number of rivets required = $\frac{54000}{4100}$ = 13.2. If the rivets are spaced 4" apart the number of rivets in a 96" web = $\frac{96}{4}$ = 24, and leaving out 1" for each rivet the effective depth = 30 - 4 = 26", and the net section = 7) x $\frac{7}{16}$ = 2344 square inches. The net tensile resistance = 2344 = 134000 lbs. As one line of rivets should be [illegible] of the web the number of rivets should be $\frac{134000}{4100}$ = 30 rivets. Two rows of rivets spaced 4" center to center will be [illegible]. The spacing between rows = $\frac{5}{8}$" which may be taken two rows of rivets on each side of the splice. Therefore, 8 plates 12" x $\frac{7}{16}$" will be used.

RIVET [illegible] IN FLANGES.

The rivet pitch is determined by the formula p = $\frac{Pa}{Sv}$.

P = the bearing value of 1 rivet = 4100 lbs.

S = the shear at the section.

a = the effective depth = 27.88 inches.

v = the moment in the web = 1 - the resisting web shear = 0.3.

p therefore = $\frac{4920 \times 92.65}{63000}$ = 7.2 inches.

The rivet pitch should in no place be smaller than 6" and at the end of the bridge it should be less than at the center. The pitch will therefore be 3" in the end panel, 4" in the 2nd panel, 5" in the 3rd panel, and 6" in all intermediate panels.

STIFFNERS.

The stiffners are to be placed at every panel point; since panel points occur every 8' the stiffners will be placed at intervals of 4'. From specifications $3\frac{1}{2}$" x $3\frac{1}{2}$" x $\frac{3}{8}$" angles are the smallest that may be used, but in order to give the flange good bearing on the stiffners 1 angle 5" x $3\frac{1}{2}$" x $\frac{3}{8}$" is used on each side of the web. The angles are to be crimped and to have a driving fit. Rivets in all stiffners are to be spaced 4" center to center.

END STIFFNERS.

The end stiffners are designed so as to transmit the end shear in the bridge to the abutments. The shear at the end equals the reaction equals 63K. The member is therefore designed as a column.

Length of column = 8'. r can not be less than $\frac{8 \times 12}{100}$ = .96.

Try 2 angles 5" x 5" x $\frac{1}{2}$" ($\frac{5}{16}$" back to back) r = 1.6.

P = 10000 - $\frac{540 \times 8}{1.6}$ = 10000 - 2700 = 7300.

$\frac{63000}{7300}$ = 8 + square inches required. From the tables the area of 2 angles 5" x 5" x $\frac{1}{2}$" equals 9.5 square inches. Therefore these angles are O. K. The rivet spacing is to be the same as in the intermediate stiffners.

UPPER LATERAL BRACING.

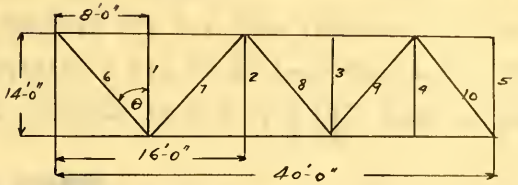


Fig. 4

The web members are alternately in tension and compression as the wind blows on opposite sides of the bridge. The members marked 1, 3 and 5 in figure 4 are not part of any cross frame but are merely substruts to help stiffen the structure. The length of the diagonals is 16.12 feet. The wind load is 300# per lin. ft. = 2400# per panel. Diagonal 6 will have the greatest stress and if this member is designed for maximum compression all other diagonals may be made the same.

The stress in diagonal 6 = the shear at the end multiplied by sec. θ. The end shear = 12000 lbs. Sec. θ = 1.15. Therefore the stress in 6 = 12000 x 1.15 = 13800 lbs.

r must not be less than $\frac{16.1 \times 12}{120} = 1.61$.

The least radius of gyration of 2 angles 6" x 4" x $\frac{3}{8}$" ($\frac{3}{8}$" back to back) = 1.60. The area of the 2 angles = 7.22 square inches.

$\frac{l}{r} = \frac{16.1}{1.6} = 10.$ Pin and square = 31250.

$\frac{31250}{5} = 6250.$ 6250 x 7.22 = 45400 lbs.

This section has a much larger area than required, but owing to the length no smaller angles can be used because of the large radius of gyration which is necessary.

LOWER LATERAL BRACING.

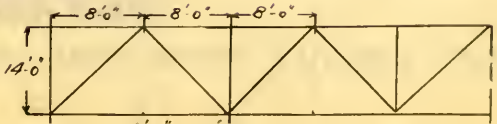


Fig. 5.

The wind load to be taken care of by the lower lateral system is one half of that which is taken by the upper lateral system, but since the members are the same length as in the upper system and take compression r can be no less than 1.6. Therefore, all members to be 2 angles 6" x 4" x $\frac{3}{8}$" ($\frac{3}{8}$" back to back)

CROSS FRAMES.

The intermediate cross frames are merely to give stiffness, and are to be made of $3\frac{1}{2}$" x $3\frac{1}{2}$" x $\frac{3}{8}$" angles. The end cross frames besides making the bridge rigid must transmit the reaction of the upper lateral system to the abutments.

R = 12000 lbs. Radius of gyration can be no less than $\frac{16.1 \times 12}{120}$ = 1.6. 2 angles 6" x 4" x $\frac{3}{8}$" ($\frac{3}{8}$" back to back) have a value of r = 1.6. From the design of the lateral bracing it was found that a column made up of 2 angles 6" x 4" x $\frac{3}{8}$" ($\frac{3}{8}$" back to back) 16.1 ft. long would carry 45400 lbs. Therefore these angles are O. K.

THE WOODEN FLOOR.

The floor of the bridge is to be 3" thick, laid in two layers. The planks are to be spiked to the wooden nailing pieces fastened to the stringers as shown on the drawing. The lower layer is to be $1\frac{1}{2}$" thick and is to consist of white oak planks; the upper layer to be of $1\frac{1}{2}$" yellow pine. The planks are to be laid diagonally accross the bridge with $\frac{1}{4}$" spaces between planks. The sidewalk planks are to be 2" in thickness, spaced $\frac{1}{4}$" apart, each plank to be toe nailed to the nailing pieces.

CURB AND GUARD TIMBER.

The curb timber between the roadway and the sidewalk and

the guard timber on the outside of the roadway are to be 6" x 4" timbers. The guard timber is to be set on 2" x 6" blocks, spaced every 5 feet to allow for drainage.

HAND RAILING.

The railing is to be made of 2" iron pipe with posts at intervals of 8 feet. The posts are to be screwed into the floor plates and all intermediate joints and connections are to be riveted. All details of the railing to be made as shown on drawing.

COST ESTIMATE OF BRIDGE.

WEIGHTS OF STEEL.

No.	Piece.	Size.	Length	Position.	Weight
8	Angles	6 x 6 x 13/16	82'-6	Flange	20460
8	"	6 x 4 x 3/8	12'-10	Cr. Frm.	1263
4	"	" " " " "	12'-9-1/2	" "	629
8	"	" " " " "	5'-10-1/4	" "	576
12	"	" " " " "	13'-10	Lateral	2032
8	"	" " " " "	13'-2-1/4	"	1298
8	"	" " " " "	14'-2-1/4	"	1396
4	"	" " " " "	14'-1-1/4	"	694
8	"	" " " " "	13'-6-1/2	"	1333
360	"	6 x 4 x 7/16	0'-5	Framing	2880
80	"	" " " " "	0'-2	"	280
8	"	5 x 5 x 1/2	7'-9-7/8	Stiffners.	1014
36	"	5 x 3-1/2 x 3/8	7'-9-7/8	"	2929
40	"	" " " " " " "	7' 10-5/8	"	3280
26	"	3-1/2 x 3-1/2 x 3/8	12'-10	Str. & Cr. Frm.	2836
8	"	" " " " "	12' 9-1/2	" " " "	870
16	"	" " " " "	5' 10-1/4	Cr. Frm.	796
4	Plates	96" x 5/16"	21'-3"	Web,	8670
4	"	96 x 5/16	20'-0"	"	8160
8	"	22-1/2 x 3/8	2' 6-1/2	Conn.	583
6	"	19-1/2 x 3/8	2' 4-3/8	"	333
5	"	16-1/2 x 3/8	2' 3-1/2	"	241
24	"	16 x 3/8	2' 0-1/2"	"	1000
4	"	14 1/2 x 3/8	1' 3-1/2	"	96
				Total-	63,969

[illegible]

No.	Place.	Time.	Position.	[illegible]
8	Anglos	6 x 3 x 15/16	[illegible]	[illegible]
3	"	6 x 4 x 1/2	[illegible]	[illegible]
4	"	" " "	[illegible]	[illegible]
8	"	" " "	[illegible]	[illegible]
12	"	" " "	[illegible]	[illegible]
6	"	" " "	[illegible]	[illegible]
4	"	" " "	[illegible]	[illegible]
6	"	" " "	[illegible]	[illegible]
38	"	6 x 4 x 7/16	[illegible]	[illegible]
30	"	" " "	[illegible]	[illegible]
6	"	5 x 3 x 1/2	[illegible]	[illegible]
32	"	5 x 3-1/2 x 3/8	[illegible]	[illegible]
40	"	" " "	[illegible]	[illegible]
16	"	3-1/2 x 3-1/2 x 3/8	[illegible]	[illegible]
8	"	" " "	[illegible]	[illegible]
12	"	" " "	[illegible]	[illegible]
4	Anglos	[illegible]	[illegible]	[illegible]
4	"	[illegible]	[illegible]	[illegible]
8	"	[illegible]	[illegible]	[illegible]
6	"	[illegible]	[illegible]	[illegible]
24	"	[illegible]	[illegible]	[illegible]
4	"	[illegible]	[illegible]	[illegible]

[illegible]

No.	Piece.	Size.	Length.	Position.	Weight.
				Forward-	63,969
5	Plates	13-1/2 x 3/8	1' 11-1/2	Conn.	168
12	"	13 x 3/8	7'-0"	Splice	1,393
4	"	12-3/8 x 3/4	2'-3"	Bed	142
5	"	10-1/2 x 3/8	1'-0"	Conn.	67
11	I Beams	15"-55#	20'-0"	Floor	12,100
90	" "	7"-20#	7'-11"	Stringer	14,250
20	" "	3"-5.5#	7'-11"	"	871
2	Channels	15"-35#	20'-0"		1,400
TOTAL					94,360

TIMBER.

160'	6" x 4" timber	Guard Rail
10'	6" x 2" "	Blocking
880'	2" x 4" "	Nailing pieces.
1600 Sq. ft.	1-1/2" White Oak	Floor.
1600 " "	1-1/2" Yellow Pine	Floor.

The cost of the bridge will be based on the following items

Steel @ \$.02 per lb.

Shop work @ \$.015 per lb.

Transportation @ \$.0025 per lb.

Erection @ \$.006 per lb.

TOTAL- - - - = \$.0435 per lb.

TOTAL COST = \$4100.

These figures allow for laying of floors, erection of railing, etc., as well as for the actual steel work and erection.

THE FILL.

By means of the profile and cross-section the volume of the cut and fill was calculated. The areas of the sections were found by the use of a planimeter and the volume figured by the method of average end areas, the distances between sections being taken from the profile.

In order to determine the cost of haul the centers of gravity of the cut and fill and supply were found. The center of gravity of the cut was found by taking the sum of the moments of each section about a certain line and then dividing by the sum of the volumes of the sections. The work was divided into three parts. First the amount of fill that the rock cut would supply was determined and the centers of gravity of the cut and fill having been ascertained the length of haul was found. The cost of the rock excavation having been assumed the cost was computed.

In the second part the remaining amount of fill on the east side of the bridge was found, and having determined the center of gravity of the supply pile and the portion of the fill the length of haul was computed. The haul is to be made by means of wheeled scrapers, the cost as given by Gillete being 9¢ per cubic yard plus 1 1/6¢ for every hundred feet of haul.

In the third part the fill on the west of the bridge was computed and it's center of gravity determined. The distance from the center of gravity of the supply to the center of gravity of this fill was found and the cost estimated for this haul.

COST OF EARTHWORK.

Haul to be done by wheel scrapers.

I.

Amount of cut = 8,080 cubic yards limestone to be used as fill from sections M to R. The length of haul from the center of gravity of cut to the center of gravity of fill is 253 feet. The cost of excavation and haul = $1.00 per cubic yard.

8080 cubic yards @ $1.00 per cubic yard = $8,080.

II.

The amount of fill from section M to the bridge = 8,490 cubic yards. The distance from the center of gravity of the supply to the center of gravity of the fill is 310 feet. The cost of loading and hauling = 14¢ per cubic yard.

8,490 cubic yards @ 14¢ per cubic yard = $1,190.

III.

The amount of fill west of the bridge = 17, 920 cubic yards. Distance from the center of gravity of the supply to the center of gravity of the fill = 585 feet. The cost of loading and hauling = 16¢ per cubic yard.

17,920 cubic yards @ 16¢ per cubic yards = $2,867.

I. - - - - $8,080

II. - - - - $1,190

III. - - - - $2,867

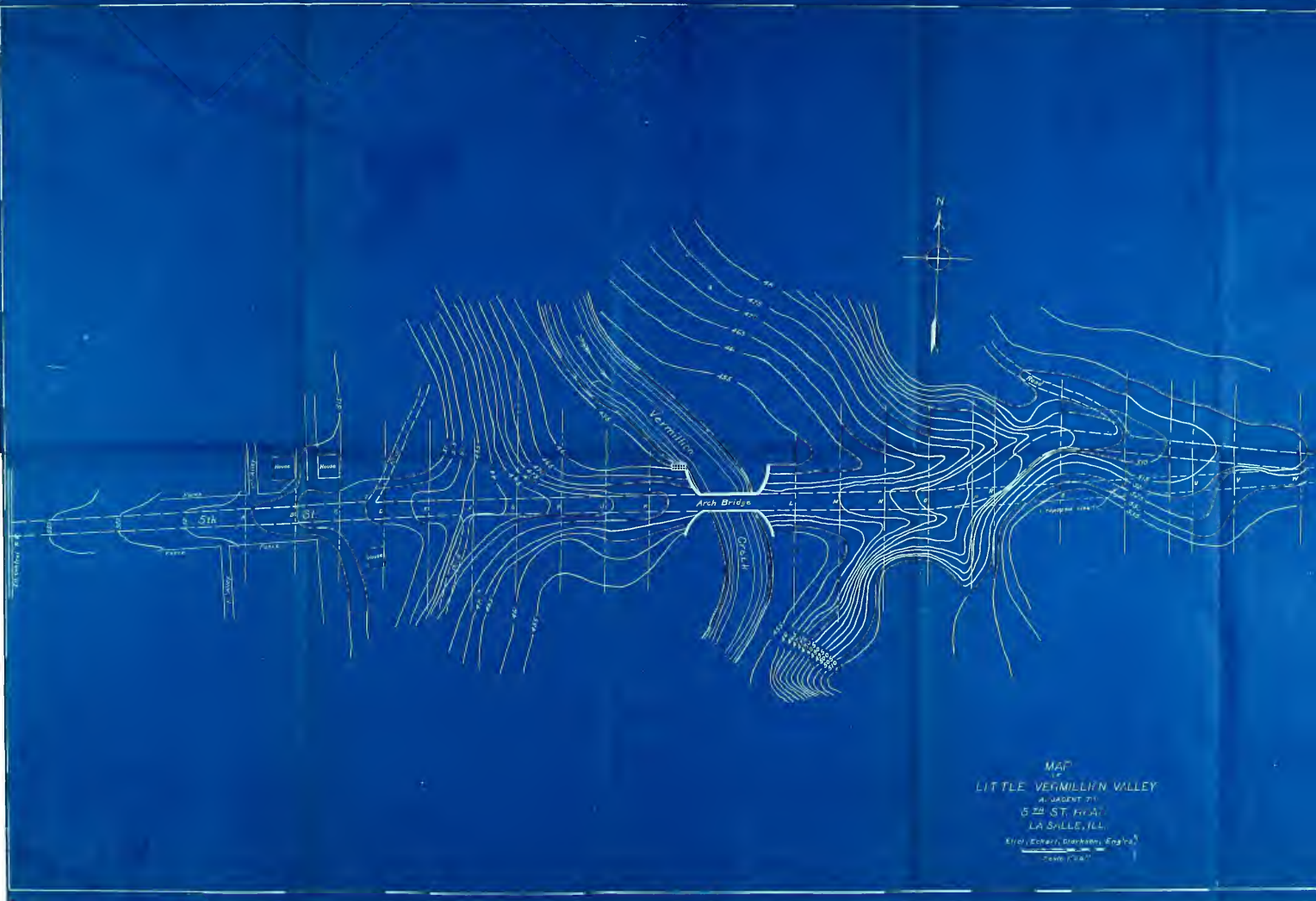
TOTAL COST OF FILL = - - - - $12,137.

FINAL.

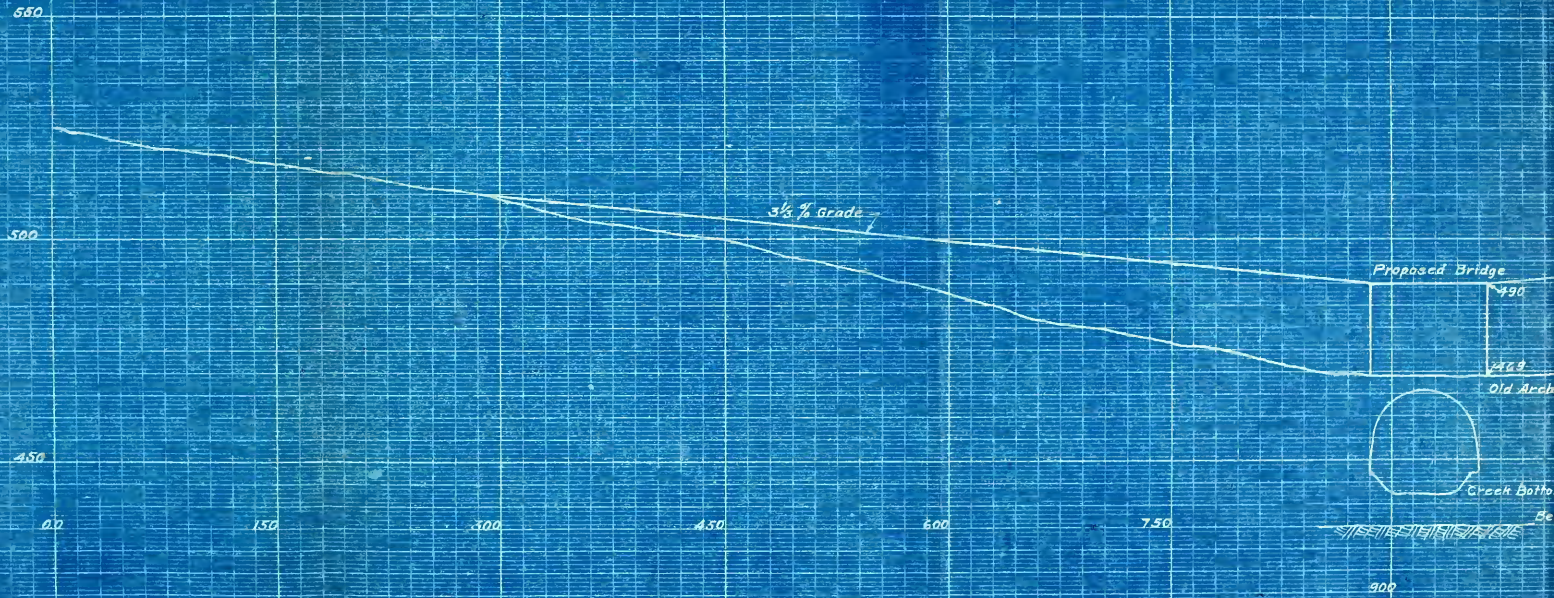
The design, details and specifications are all according to standards in use at the present time and the entire work is figured according to standard texts. The cost estimates are based upon average costs of labor and material according to the present scale of prices as they have been applied to similar work which has already been carried out.

The total cost of the improvement as figured according to the foregoing designs and estimates is as follows:-

Concrete - - - - - - - -	$11,976
Bridge - - - - - - - -	$ 4,100
Earthwork - - - - - - - -	$12,137
TOTAL COST - - - - - - -	$28,213

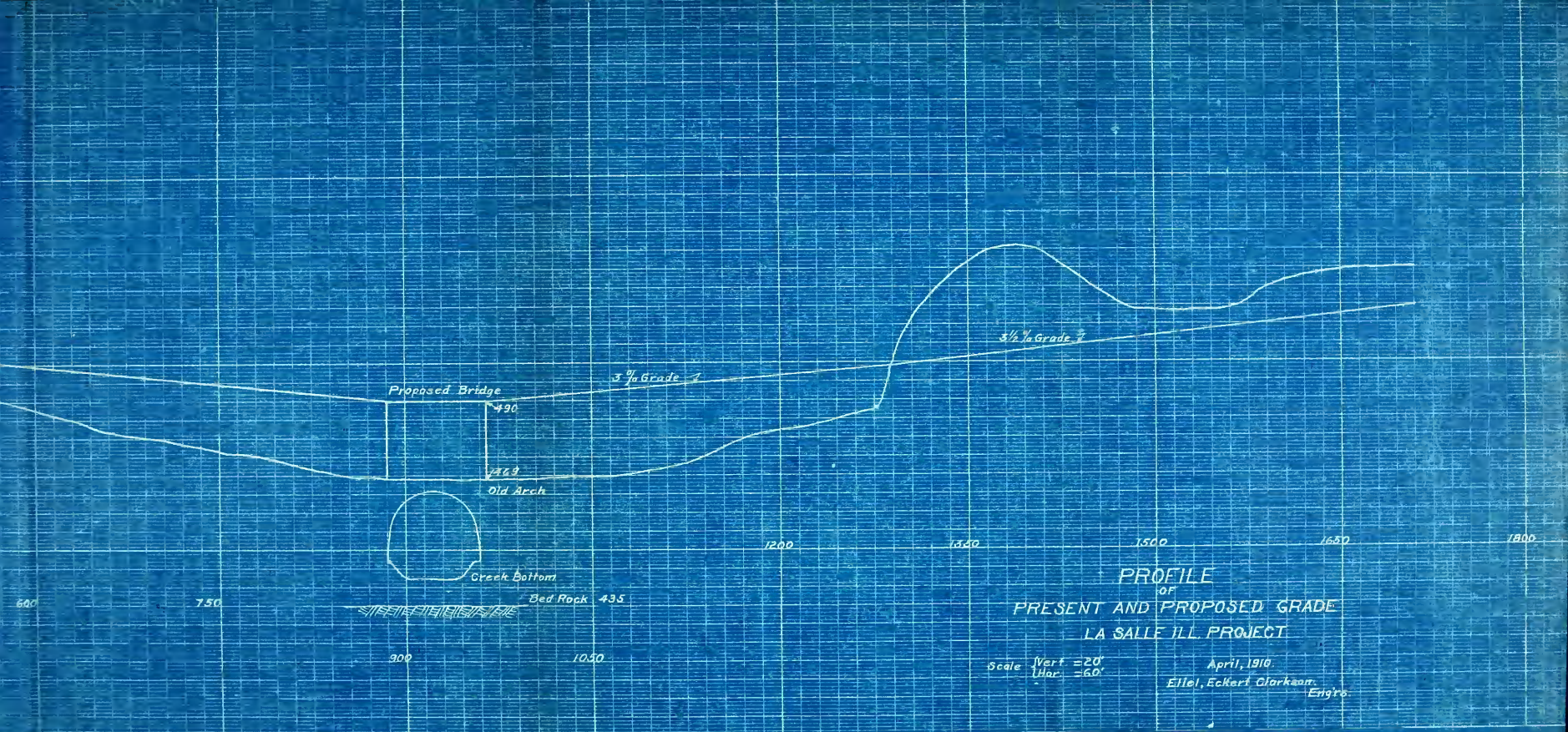


MAP
OF
LITTLE VERMILLION VALLEY
ADJACENT TO
5TH ST. HILL
LA SALLE, ILL.
Kroh, Eckert, Clarkson, Engrs.
Scale 1" = 50'



STANDARD PROFILE PLATE A 4X20
KEUFFEL & ESSER Co NEW YORK

STANDARD PROFILE PLATE A 4X20
KEUFFEL & ESSER Co NEW YORK



PROFILE
OF
PRESENT AND PROPOSED GRADE
LA SALLE ILL. PROJECT

Scale Vert. =20'
Hor. =60'

April, 1910.
Ellet, Eckert Clarkson.
Engrs.

STANDARD PROFILE PLATE A 4X20
KEUFFEL & ESSER Co NEW YORK

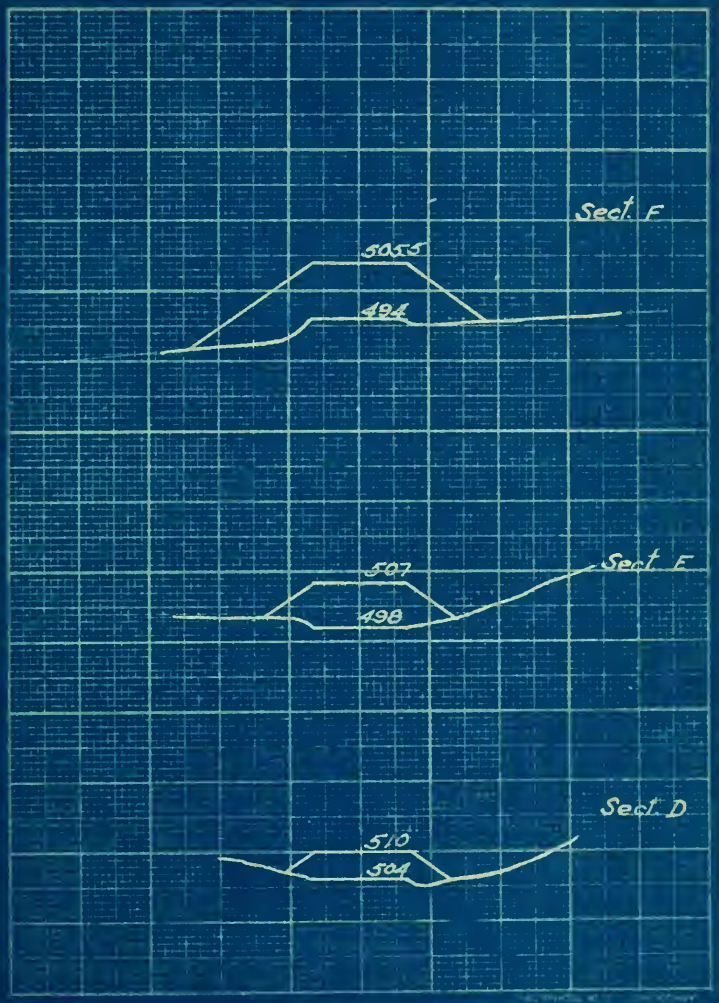
STANDARD PROFILE PLATE
KEUFFEL & ESSER Co NE

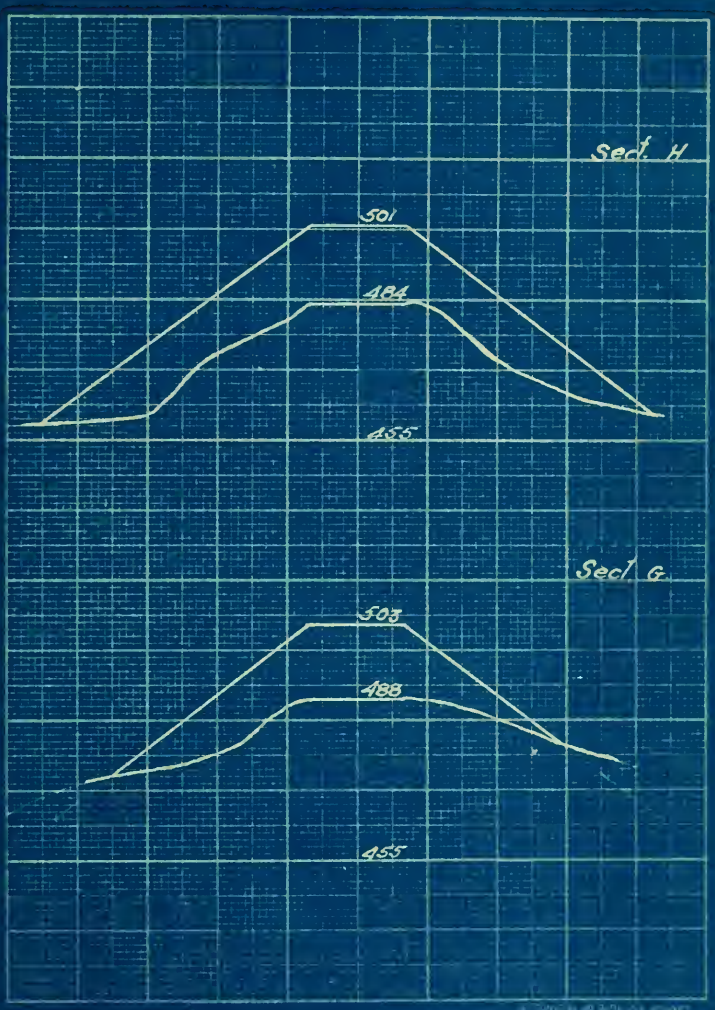
Sect. C

Sect. B

CROSS SECTIONS
SHOWING
CUT AND FILL

Scale 30'=1"


Sect. F
505.5
494
507
498
Sect. E
Sect. D
510
504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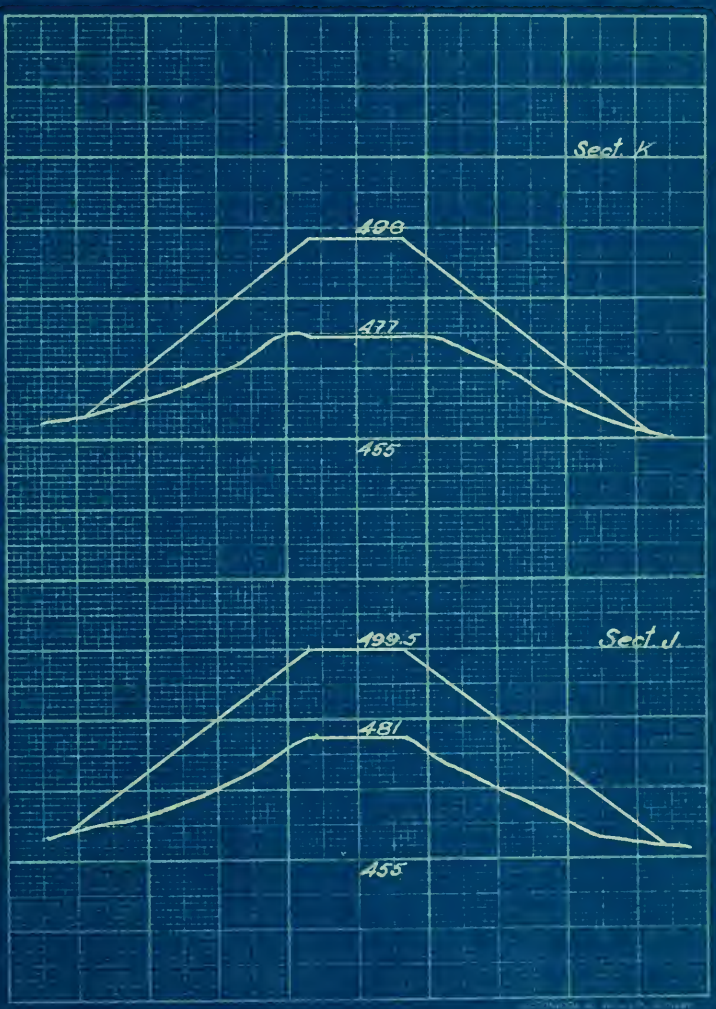
501
484
455
Sect G.
503
488
455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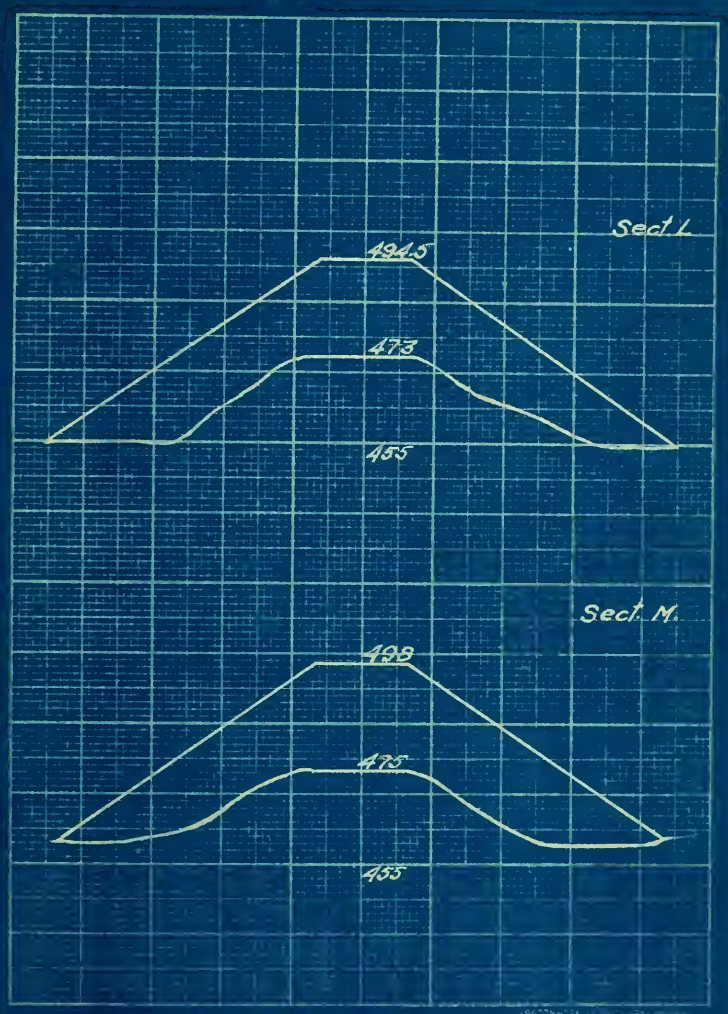
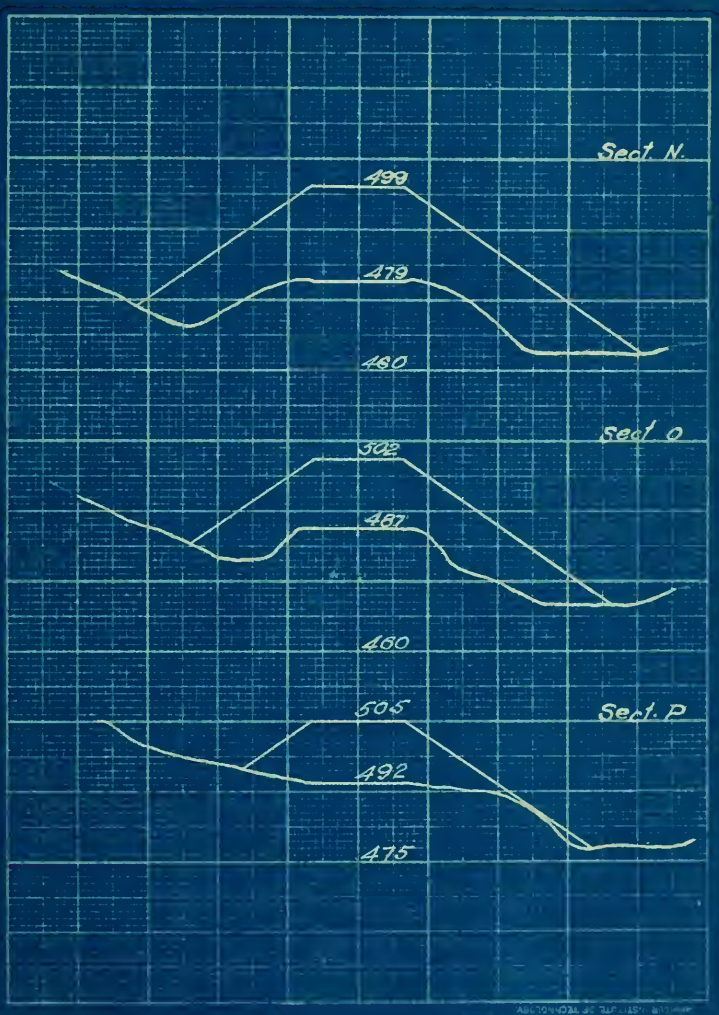
498
477
455
Sect. J
499.5
481
455


Sect L
494.5
473
455
Sect. M.
498
475
455


Sect. N.
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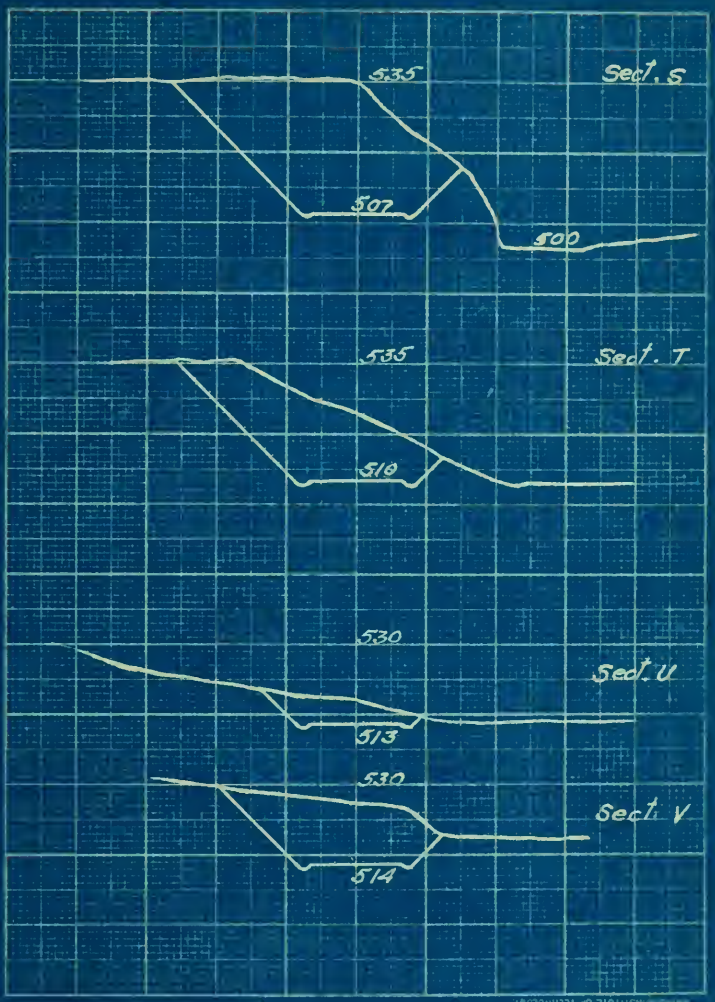
479
480
Sect. O
502
487
480
Sect. P
505
492
475

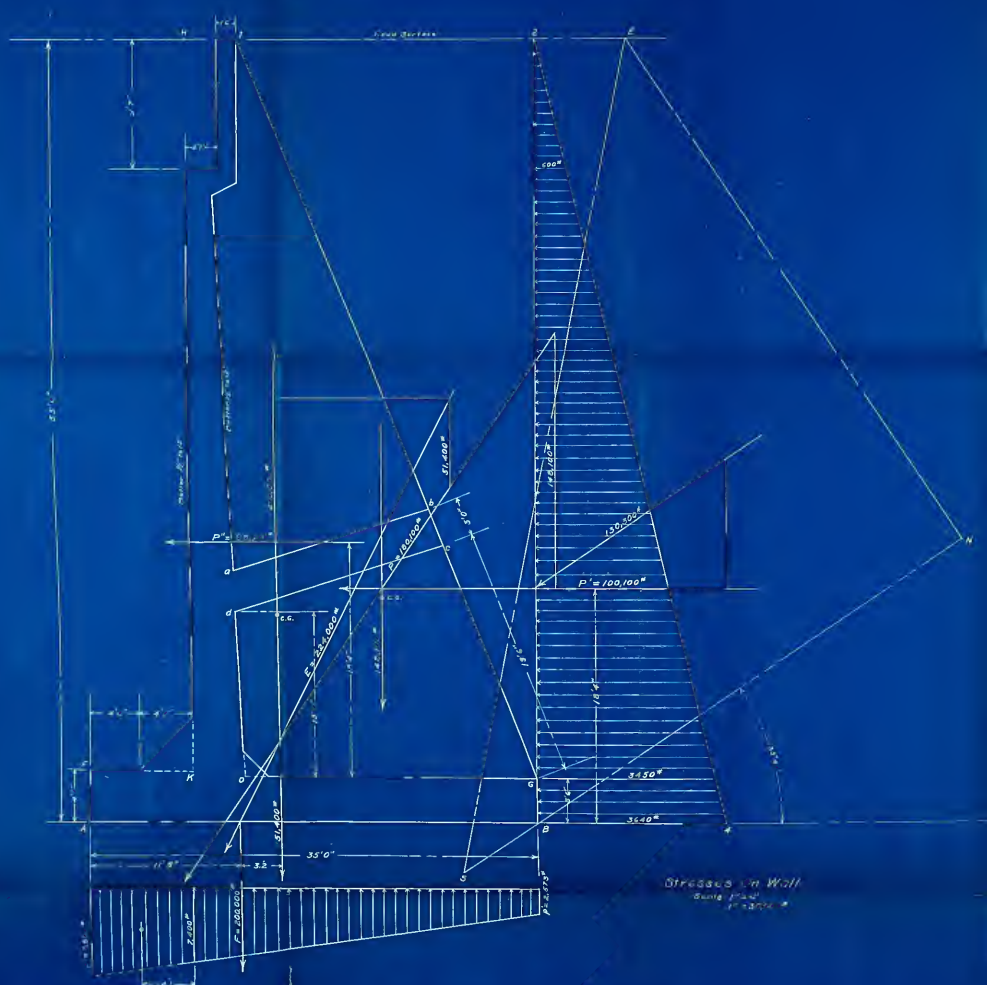


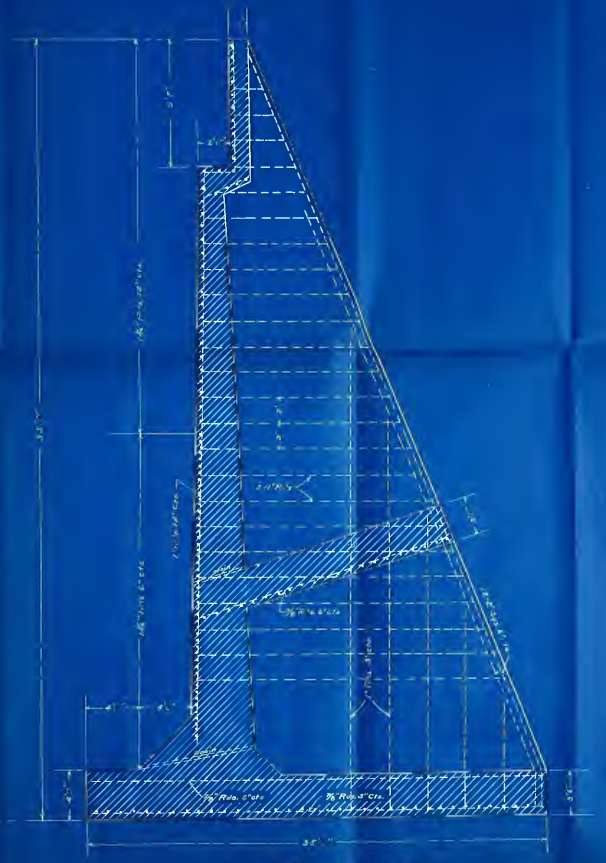
M.I.T. LIBRARIES MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Cut and Fill.

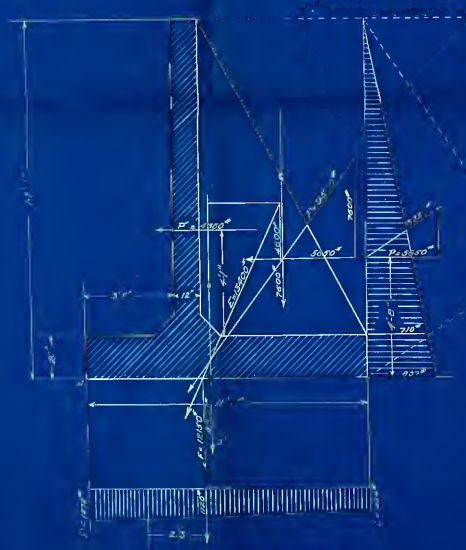
ARMOUR INSTITUTE OF TECHNOLOGY

Sect.	Area Sq. Ft.	Average End Area.	Length Ft.	Vol. Cu. Ft.	Vol. Cu. Yds.	
A	0					
		49	60	2940	109	
B	98					
		148	60	8880	329	
C	198					
		189	60	11340	420	
D	180					
		234	60	14040	521	
E	288					
		423	60	25380	940	
F	558					
		792	60	47520	1763	
G	1026					
		1296	60	77760	2871	
H	1566					
		1606	60	96360	3568	
J	1647					
		1566	60	93960	3480	
K	1485					
		1764	120	211680	7830	
L	2043					
		2056	60	123360	4575	
M	2070					
		1791	60	107460	3981	
N	1512					
		1255	60	75300	2790	
O	999					
		789	60	46140	1710	
P	540					
		270	30	8100	300	
R	0					
				Total Fill	35187	Cu. Yd.
R	0					
		922	90	50220	1934	
S	1116					
		436	90	82980	3070	
T	729					
		436	90	39240	1455	
U	144					
		365	60	21900	811	
V	486					
		243	90	21870	810	
W	0					
				Total Cut	8080	Cu. Yd.

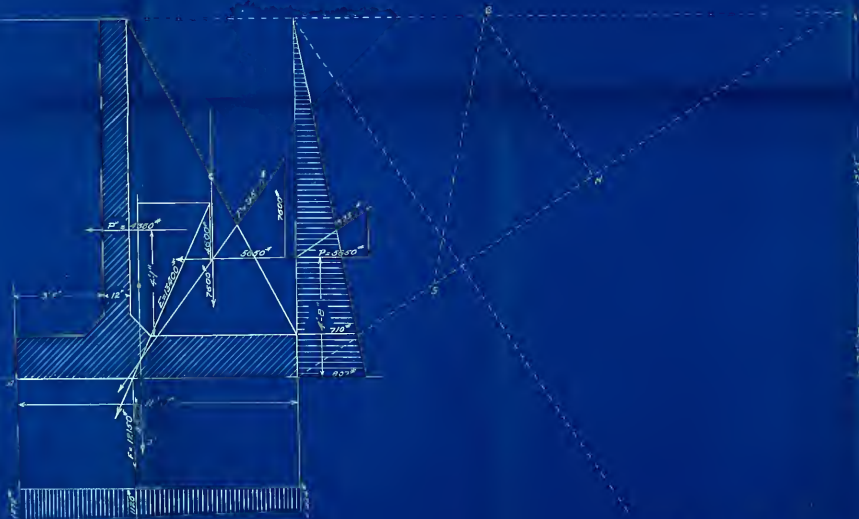




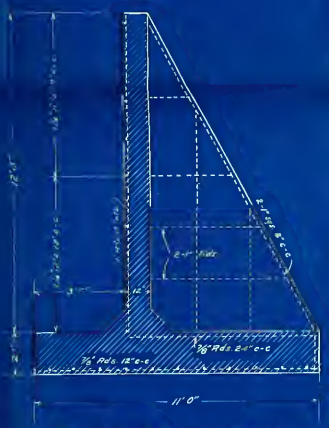
ABUTMENT
Scale 1"=10'
Elliot, Robertson & Clarke



STRESSES IN END OF WING WALL.



DESIGN OF LOWER END OF WING WALL.



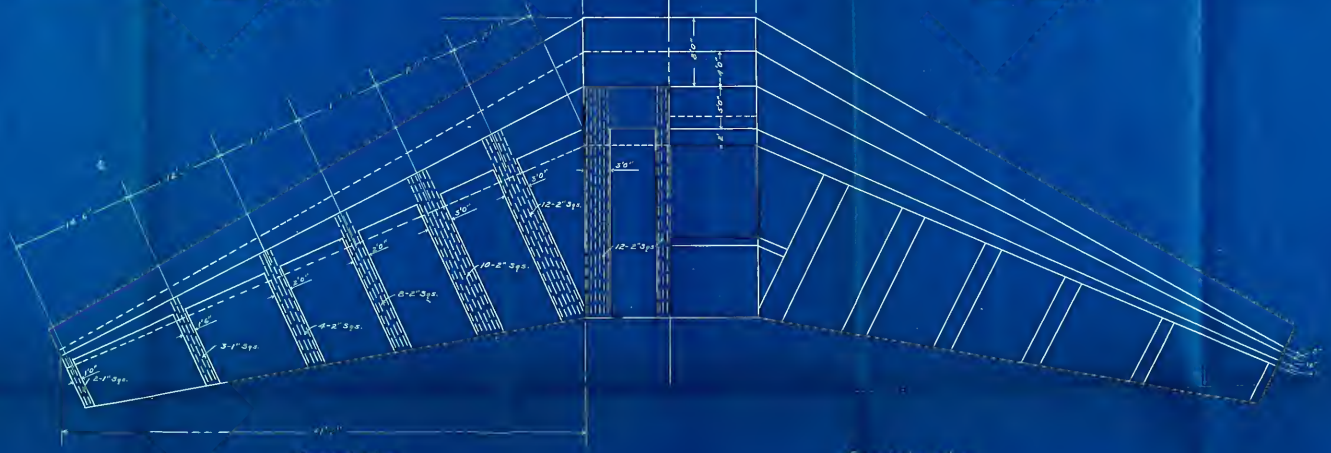
SECTION AT END OF WING WALL

WING WALL

Scales 1" = 2'-0"
1" = 4'-0"

April, 1912.

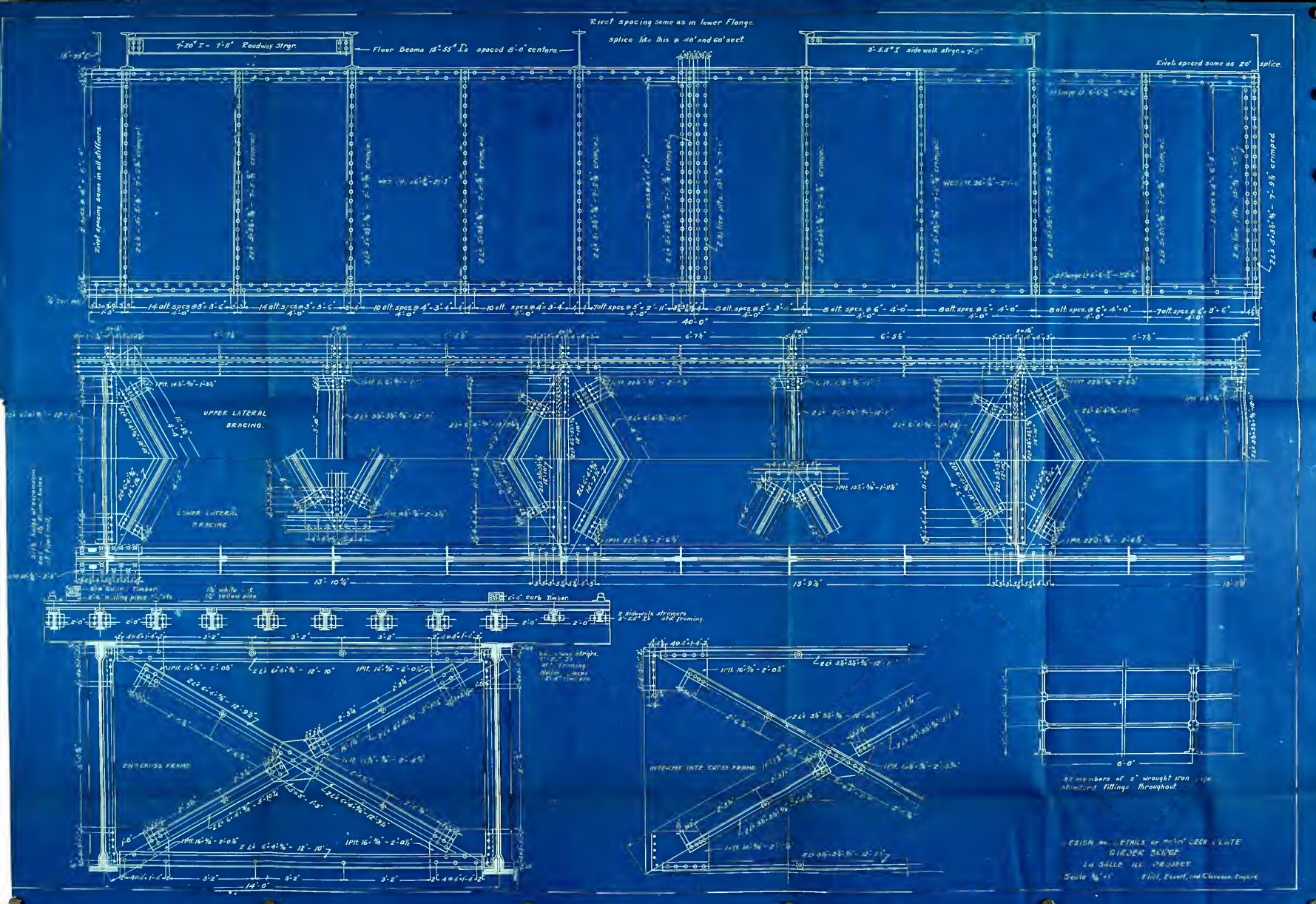
Elliott, Cheney and Chittenden



DETAILS

Scale 1"=8" Architect

Elliot, Eckert, & Clarke


Rivet spacing same as in lower flange.
Splice like this @ 40' and 60' sect.
7'-20" I - 7'-11" Roadway Strgr.
Floor Beams 15"-55# I's spaced 8'-0" centers
3'-5.5"# I side walk strgr. = 7'-11"
Rivets spaced same as 20' splice.
Rivet spacing same in all stiffners.
14 alt. spcs @ 3'-6" = 49'-0"
14 alt. spcs @ 3'-6" = 49'-0"
10 alt. spcs @ 4'-3" = 42'-6"
10 alt. spcs @ 4'-3" = 42'-6"
7 alt. spcs @ 5'-2"-11" = 36'-5"
8 alt. spcs @ 5" = 40'-0"
8 alt. spcs @ 5" = 40'-0"
8 alt. spcs @ 6" = 48'-0"
8 alt. spcs @ 6" = 48'-0"
8 alt. spcs @ 6" = 48'-0"
7 alt. spcs @ 6" = 42'-0"
40'-0"
UPPER LATERAL BRACING.
LOWER LATERAL BRACING
15'-10 1/4"
13'-9 1/4"
6"x6" Guard Timber
8"x8" milling piece 7'-6" c/c
12" white oak
10" yellow pine
6"x6" curb Timber.
2 sidewalk stringers 7"-22.5# I's and framing.
END CROSS FRAME
INTERMEDIATE CROSS FRAME
All members of 2' wrought iron pipe throughout.
DESIGN AND DETAILS OF PLATE GIRDER BRIDGE
LA SALLE ILL. PROJECT
Scale 1/4"=1'
Elliott, Ensrud, and Clarendon, Engrs.